

METHOD AND APPARATUS FOR ORDER INDEPENDENT  
PROCESSING OF VIRTUAL PRIVATE NETWORK PROTOCOLS

BACKGROUND OF THE INVENTION

The present invention relates to virtual private networks for data packet communication and particularly to methods and apparatus for providing security gateway service to such networks.

5 Many secure or semi-secure networks exist today, which, by limiting physical access and data communication access by others, can boast a high degree of information privacy. It is desirable to permit such secure networks to communicate with sources external to  
10 the network such as remote user telecommunicators and accordingly, some means is needed to maintain the privacy of the secure network. Security gateways have been employed to limit access to and from users outside the actual secure network. Such gateways originally  
15 screened those on the outside who were allowed to communicate over the secure network and also limited the services on the network which could be accessed by outsiders. Such original gateways did not secure the communication outside the secure network and as a result  
20 undesired communicators or communications may have had access to the secure network.

Virtual private networks (VPN) have evolved in an attempt to improve the security outside of the secure network for communicators which are permitted to enter  
25 or leave the secure network. VPNs are created by using available protocols for creating what are called VPN tunnels through a public network. The VPN protocols consist of methods for authentication, encryption, compression and otherwise protecting a data packet  
30 "payload" while communicating the packet through the public data network using normal, unencrypted public network addresses. Such normal unencrypted addresses

include Internet Protocol (IP) addresses which identify the source and destination for each packet conveyed by the network. A security gateway receives the VPN packets, authenticates the communication and processes 5 the payload in accordance with the particular VPN protocol(s) employed. The public network source and destination addresses may then be discarded and IP addresses from the protected payload used to communicate with the secure network.

10 The VPN protocols use preselected and/or negotiated encrypting and compressing methods and may employ public and private keys to process the VPN packets. The encryption keys for decrypting the particular encrypting and compression algorithms for a given communication may 15 be known in advance to the VPN user and security gateway. When pre-known, they are stored in a security association (SA) database in the security gateway and used to process packets going to and from the public network. Known security gateways, however, store the SA 20 in association with a public network IP address. As long as a given user is assigned or constrained to use the same IP address, the proper SA parameters will be identified at the security gateway. This is not how public networks normally function and accordingly, non- 25 standard operation is needed and inefficient usage of IP addresses results.

In a normal dial-up public network connection, a user establishes a telephone connection to his or her internet service provider (ISP) which assigns an IP 30 address to the user from a pool of available IP addresses. All communication with the user until the telephone connection is dropped uses the assigned user IP address. If the user drops the telephone connection to the ISP and then establishes a new one, a new IP 35 address may be assigned to the user. Since the IP address of the user may change over time, a security gateway cannot establish an SA entry for that user since

it cannot be identified by a consistent IP address. Additionally, problems exist in the security gateway itself regarding the unpacking of a VPN payload. For full security at the secure network it is important that  
5 the VPN payload be decrypted and compressed before the security network is entered. An incoming packet, however, may have been processed in accordance with any of a number of VPN protocols and sometimes by multiple VPN protocols in sequence. Unless the payload is  
10 treated in accordance with the same protocols in the reverse sequence in which they were used to create the payload, the content of the payload will be lost. Prior VPN systems have matched packets closely to gateway processes which are identical in a reverse sense to the  
15 encryption protocols. Thus, it must be known a priori what VPN protocols have been used and their sequence of use and one or more processing modules must be provided for each combination of protocols. This leads to inefficient use of hardware or processor time. Thus,  
20 the possibility of using multiple VPN protocols creates additional problems in the art.

#### SUMMARY

A method and apparatus in accordance with the present invention receives VPN packets processed in  
25 accordance with one or more VPN protocols and properly terminates those protocols in the appropriate sequence. A security gateway receives VPN control and data packets communicated between a public data network and a corporate network. As initial control packets are  
30 received they are authenticated and rules and procedures are identified for proper treatment of VPN data packets bearing the same source IP address. The rules and procedures are stored in a gateway data engine having a plurality of protocol processing modules.  
35       VPN data packets are received by a protocol

discriminator which reads the stored rules and procedures identified for the source IP address of the received packet. The discriminator passes the received packet to a first protocol module as identified in the 5 stored rules and procedures. After the first module completes processing, the packet is passed back to the protocol discriminator which determines whether further protocol processing is required. When further protocol processing is required, the packet is passed to another 10 protocol module for processing in accordance with another protocol. At the completion of processing, the second protocol module returns the packet to the protocol discriminator. When the protocol discriminator determines that no further protocol processing is 15 required, the packet as processed by one or more of the protocol modules is sent on to a packet filter and address translator for transmission to the corporate network. In a similar but reverse manner, the gateway data engine receives packets from the corporate network 20 and processes them in the proper sequence using the plurality of protocol modules.

Advantageously, a first of the protocol modules processes layer 2 VPN protocols such as point-to-point tunneling protocol (PPTP) and layer 2 tunneling protocol 25 (L2TP). Another of the protocol modules handles layer 3 VPN protocols of which the IP security (IPSec) protocol is an example. By operation in accordance with the embodiments herein, packets having layer 2 or layer 3 VPN tunnels or a combination of layer 2 and layer 3 30 tunnels can be properly terminated at a gateway and created at the gateway for transmission to a user (client) via a public data network.

#### BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present 35 invention will be gained from consideration of the following description when read in conjunction with the

drawing in which:

FIG. 1 is a block diagram representing communication with a secure network through a public network;

5 FIG. 2 is a block diagram of portions of a security gateway of FIG. 1;

FIG. 3 represents a virtual private network from a user/client to a secure network;

10 FIG. 4 represents a virtual private network from an internet service provider to a secure network;

FIGs. 5(a) and 5(b) are block diagrams representing virtual packet protocol structure and construction from a user/client to a secure network; and

15 FIG. 6 is a block diagram of an embodiment of a gateway data engine of FIG. 2.

#### DETAILED DESCRIPTION

FIG. 1 illustrates a data network system in which a public network 101, such as the Internet, is used to interconnect users 102, 103 and 104 and a secure 20 corporate network 105. Users 102 and 103 are connected to the public network 101 via an internet service provider (ISP) 106. User 104 is connected to the public network via a corporate network 107 and a gateway server 109. Communications between the corporate network 105 and the public network 101 are controlled by a security 25 gateway 111 which provides, among other services, virtual private network services and data filtering services for corporate network 105. Public network 101 is a TCP/IP network and communication is by means of IP 30 addressed datagrams or packets. In order to provide communication security, users 102-104 may communicate with corporate network 105 over virtual private networks (VPN) which are represented as 113, 115 and 117.

A VPN consists of an encrypted data payload which 35 is transmitted by the communicating endpoints with non-

5        encrypted source and destination IP addresses for  
conveyance by the public network. Due to the protocols  
employed to establish the VPN, the payload is protected  
from security threats in the public network giving  
10      secure networks such as corporate network 105 the  
confidence to allow the exchange of data over the public  
network. Many different systems exist for creating and  
using VPN. The different systems involve different  
types or choices of encryption and rely on different  
15      encryption keys for proper processing. Additionally,  
some VPN protocols allow compression and provide  
internal authentication of the data in the payload.  
Lastly, the different protocols may operate at different  
layers of the open systems interconnection (OSI) model.

15      A virtual private network begins with a request  
from a user, such as user 102, to dial up ISP 106. The  
ISP authenticates the user by login and password with a  
protocol such as the well-known RADIUS and, upon proper  
20      authentication, assigns the user an IP address from a  
pool of IP addresses controlled by the ISP. The user  
then begins a process for the establishment of a VPN  
using the assigned IP address to set up a channel for  
session level authentication at the security gateway  
111. The first packet transmitted to the security  
25      gateway identifies as a non-encrypted destination, the  
IP address of the gateway 111 and includes internal data  
which the gateway interprets as a request to establish a  
session. The internal data will include among other  
items, user name, e.g., client 102, password and a  
30      security ID. The packet will be conveyed to a data  
engine 121 (FIG. 2) of the security gateway 111. The  
data engine interprets the packet as a control packet  
and forwards it to a gateway controller 122. The data  
portion or payload of the first packet will be encrypted  
35      in a manner known by the gateway controller 122 which  
initiates a controller thread to manage the requested  
session. Initially, the controller thread decrypts the

packet data, identifies the user identity, password and security ID. An authentication protocol such as RADIUS is then performed to authenticate the user's access. If authentication fails, the connection is dropped.

- 5 Alternatively, if authentication is successful the controller thread begins the processes needed to establish and maintain a VPN connection.

The VPN is in essence an encrypted payload which negotiates the public network by means of non-encrypted 10 source and destination IP addresses. The user's IP address is the IP address assigned by the ISP. The security gateway IP address is previously known to the user. The encryption of the payload, including data encryption, data authentication and compression, 15 requires that both the user and the security gateway are aware of the types of encryption, authentication and compression being employed and that any necessary keys have been exchanged. If this is a first communication from a user to the security gateway, a negotiation will 20 take place to properly inform both the user and the gateway how the payload is to be processed. Such negotiation is known in the art and not discussed in detail herein. The parameters representing the negotiated keys and protocols are then stored in the 25 user's computer and in a Security Association (SA) in the storage 124 of the security gateway. The SA is stored in a table with the SAs for other VPNs and is accessible using the user's user identity. If the present request for a VPN is not the first communication 30 between security gateway and the user, the gateway controller accesses the previously negotiated SA from storage 124, stores it in the gateway data engine 121 and binds it to the IP address of the user as assigned by the ISP. As subsequent packets are received in the 35 same session, the data engine 121 accesses the SA bound to the assigned user IP address and properly decrypts the packet payload. At the end of the session the

gateway controller unbinds the SA from the assigned IP address.

After the user of a VPN is authenticated, VPN packets can be properly received and decrypted for communication on the corporate network 105 and packets from the corporate network can be encrypted and sent to the user 102. The security gateway also includes features to potentially limit each user's access to parts of the corporate network. It is therefore necessary to identify the policies and conditions under which the user will be permitted to exchange packets with services on the corporate network. The exchange of packets is controlled by a packet filter which operates in accordance with data defining a user's access to corporate network services to actually grant or deny access to the network. The database of the gateway controller stored in storage 124 includes user identity bound service mappings which define user access to the corporate network. The user identity which is obtained after authentication of the user, is used to access the database of the gateway controller for the service mappings bound to that user identity. Those service mappings are forwarded to memory of the data engine and bound to the ISP-assigned IP address of the user. As each VPN packet is received and decrypted it is sent on to a data filter for granting or denying access to the corporate network. Similarly, packets from the corporate network containing the user's assigned IP address are screened by the data filter before being encrypted and sent on to the user via the VPN.

The preceding description assumed that the VPN was terminated at the user end in the user computer 102 and at the other end in the security gateway 111. FIG. 3 shows a VPN connection from user 102 to security gateway 111 via the single bold colored connection 127. FIG. 4 shows an alternative VPN connection in which a normal (non-VPN) PPP connection exists between user 102 and

security gateway 111. In FIG. 4 the VPN termination for the user resides in the ISP 106. Accordingly, user 102 communicates with the ISP106 via a normal PPP connection 129. The VPN termination 139 in the ISP then properly  
5 encrypts and decrypts payloads destined for the VPN termination 133 of security gateway 111. It should be mentioned that the VPN terminations 137 and 133 and 139 and 133 must be compatible so that packets can be properly communicated.

10 A plurality of VPN protocols are available today and it is expected that more will be available in the future. Some of these protocols operate at layer 2 of the open systems interconnection model and some operate at layer 3. The various VPN protocols provide different  
15 methods of encryption, authentication and compression such that both ends of a VPN must practice the same protocol. Layer 2 protocol solutions include point-to-point tunneling protocol (PPTP) and layer 2 tunneling protocol (L2TP). For PPTP the VPN tunnel originates at a PPTP access concentrator (PAC) and terminates at a PPTP network server (PNS). The comparable entities in L2TP are the L2TP access concentrator (LAC) and the L2TP network service (LNS). When a layer 2 VPN tunnel is established between a client and a security gateway  
20 (FIG. 3), the PAC or LAC is the VPN termination 137 on the client 102 and the PNS or LNS is the VPN termination 133 on the security gateway 111. Similarly, when a layer 2 VPN tunnel is established between an ISP and the security gateway 111 (FIG. 4), the PAC or LAC resides at  
25 the ISP for communication with the PNS or LNS at the gateway. A layer 3 tunneling protocol is represented by the IP security protocol suite (IPSec) which also provides a set of features by which a secure VPN communication may be undertaken. IPSec can be used to  
30 provide a VPN tunnel between a client and a security gateway or between an ISP and a security gateway as shown in FIGS. 3 and 4, respectively.  
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The layer 2 and layer 3 protocols are not described herein in detail as they are well known in the art. The establishment of a VPN tunnel in a given protocol requires a predetermined capability set at both ends to

5 continue the tunnel and the capabilities of one protocol will not complete a tunnel with another protocol. Thus, each VPN protocol requires specific termination.

10 Additionally, it is possible that VPN tunnels will be created which include attributes of more than one protocol. For example, security demands may require the establishment of a tunnel within a tunnel such as a layer 2 tunnel within a layer 3 tunnel. That is, a first set of layer 2 protocols may be employed to

15 packets, then a second set of layer 3 protocols before they are sent to the network, e.g. 101. The security gateway must then perform the proper layer 2 and layer 3 protocols in the reverse order to properly obtain the packet payload.

FIGs. 5(a) and 5(b) are block diagrams representing two examples of a first security protocol being tunneled within a second security protocol which result is sent over the public network. FIG. 5(a) represents an IPsec protocol tunneled within a PPTP/L2TP protocol which forms the payload of packets exchanged over the public between client 102 and gateway 111. In FIG. 5(a) the client 102 includes an IPsec protocol unit 251 which first handles packets of data and conveys the treated packets to a PAC/LAC protocol unit 253. After the protocol unit 253, the packets are given IP source and destination addresses for conveyance over the public network via communication path 127.

FIG. 5(a) includes a plurality of packet representing rectangles 255, 257, 259 and 261 each representing security protocol results of packet handling at portions of the communication path. In rectangle 255, representing packets on communication path 127, original user data 263 is incorporated with in the IPsec protocol represented by the bracketed items

265. It should be mentioned that the TCP/UCP included  
within 265 refers to the well known Transmission Control  
Protocol or the User Datagram Protocol. Additionally,  
the content of bracketed items 265 is processed in  
5 accordance with the PPTP/L2TP protocol as represented by  
267. Lastly, the result is collected into a PPP (point-  
to-point protocol) packet 269 for communication over the  
public network. At the security gateway 111, the PPP  
10 protocol is resolved and the PPP source and destination  
addresses IP3 are used for proper handling by the  
PNS/LNS protocol unit 271. Thereafter, the remaining  
packet portions 263 which include a source and  
destination address IP2 are used by the IPSec protocol  
15 unit 273 to finally resolve the incoming packet into the  
data 263, protocol and IP address IP1 originally  
provided by its user. The reverse operation of  
constructing and transmitting packets is also performed  
by processing in protocol units 273, 271, 253 and 251 in  
sequence.

20 FIG. 5(b) is not described in detail herein but it  
represents the same protocol-within-protocol packet  
handling as illustrated in FIG. 5(a) except that the  
sequence of the protocol units 251 and 253 is reversed  
as is the sequence of the protocol units 271 and 275.  
25 Whereas the security gateways of FIGS. 5(a) and 5(b)  
must be closely matched to their communicating clients,  
FIG. 6 illustrates a data engine for a security gateway  
which does not require identical protocol matching to  
that of the client.

30 FIG. 6 is a block diagram of a gateway data engine  
121 (see FIG. 2) capable of applying proper protocols to  
incoming packets to provide proper VPN tunnel  
termination for layer 2 and 3 protocols as well as for  
packets treated in accordance with multiple protocols.  
35 It should be mentioned that additional protocols to  
those referenced in FIG. 6 may be terminated by the  
gateway by providing additional modules similar to  
modules 205 and 207 for the additional protocols. The

illustrated gateway data engine also provides necessary firewall features such as packet filtering and translation of network addresses.

The gateway data engine 121 of FIG. 6 receives  
5 packets at a protocol discriminator 201 which inspects  
packets incoming from the public network to identify the  
type of processing needed. As discussed above, VPN  
packets received by the gateway data engine of the  
10 security gateway (FIG. 2) identify their IP source and  
destination addresses for conveyance through the public  
network. Further, the initial packet or packets of a  
session are control packets which are sent to the  
gateway controller from which authentication is  
achieved. The gateway controller (FIG. 2) as a part of  
15 session establishment also identifies the policies for  
the VPN protocol employed for each packet. These  
policies are bound to the source and destination  
addresses associated with packets. The gateway  
controller 122 then writes into memory 203 the nature  
20 policies of protocol processing needed for incoming  
packets having the source and destination addresses of  
the subject packet. After the session is authenticated  
and the memory 203 is written, data packets are received  
at the data engine 121 by a protocol discriminator 201.  
25 Based on the source and destination addresses of an  
incoming packet, protocol discriminator 201 identifies  
which protocols are to be employed using policies  
associated with these addresses. When layer 2 protocol  
is to be first used, the packet is passed to a layer 2  
30 processing module 205 which processes the packet in  
accordance with a predetermined layer 2 protocol (e.g.  
performs the function of a PNS or LNS) and returns the  
processed packet to the protocol discriminator 201. The  
discriminator then determines if layer 3 protocol  
35 processing should be done and if so, the packet is sent  
to a layer 3 processing module 207. At the completion  
of layer 3 processing the packet is returned to protocol  
discriminator 201 and forwarded to a firewall processing

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module 209 for packet filtering and address translation. When the protocol discriminator receives a packet from the public network, it may first require layer 3 processing. In such a case the packet will first be  
5 sent from protocol discriminator 201 to layer 3 processing module 207. At the completion of layer 3 processing the packet is returned to the protocol discriminator 201 from which it may be passed to the layer 2 processing module 205 or directly to the  
10 firewall module 209 as identified by the protocol data in memory 203.

Packets received by the gateway data engine from the corporate network, e.g. 105, are passed through the firewall module 209 to the protocol discriminator 201.  
15 Based on the source and destination addresses of packets from the firewall module 209, the protocol discriminator passes the packet on to the layer 3 processing module 207 and/or the layer 2 processing module 205 as needed to properly communicate through the public network 101  
20 with the communicating client, e.g. 102. After processing by the gateway data engine, the packet in proper VPN format is sent to the public network 101.

It is understood that the above described embodiments are merely descriptive of the principles of the invention and that many variations may be devised by those skilled in the art without departing from the scope of the invention. It is intended that such variations be included within the scope of the claims.  
25